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John E. Parsons

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LONG-TERM CONTRACTS: A MODEL FOR ASSESSING THEIR IMPORTANCE IN FINANCING NATURAL GAS PROJECTS

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INTRODUCTION

The vast majority of natural gas field development and LNG projects are organized and financed using long-term take-or-pay contracts for the sale of the gas. These contracts serve two main purposes. First, they coordinate the plans and commitments of the buyer and the seller. Since natural gas projects typically require large capital investments dedicated to a small set of buyers and since the salvage value of the equipment is a tiny fraction of the investment it is important to obtain a commitment from the buyers before the investment is sunk. Second, the obligations on both sides of the contract--the price terms, the indeces, and the quantity flexibility--allocate the risks of the project among the parties. The first of these two purposes--the need for commitment--is the subject of this paper. We provide a model with which to estimate the portion of a project's value that is secured to the developer through the use of long-term contracts for the sale of the gas.

While it is common sense that a long-term contract is beneficial to a gas field developer because it offers security that the capital investment will earn a sufficient return, project analysts currently have no tool with which to carefully assess the significance of this benefit. A measure of the benefits of long-term contracts is becoming increasingly important to project analysts in the natural gas industry as the options for contracting and financing development expand. In past decades the need for security in the natural gas industry was deemed so great that a long-term contract was accepted as a matter of course despite the large costs that sometimes arise when the inflexible parameters of the contract are eventually out of line with realized market conditions. This is no longer the case. It is commonly believed that increased flexibility in contracting and an increased reliance upon short-term sales are becoming important elements of natural gas project development and financing world-wide. That is, the benefits of strong commitments in long-term contracts must be more carefully weighed against the costs imposed by the inflexibility that these contracts impose. Unfortunately there do not currently exist any commonly used techniques for evaluating the strategic benefits to long-term contracts that would enable a developer to make this comparison in a careful and informative fashion.

The model presented in this paper fills this gap. Our analysis is made in the context of a typical discounted cash flow analysis of a project. We show how the anticipated probability distribution of prices that the developer can expect as a consequence of selling the gas through long-term contracts will differ from the distribution of prices that the developer can expect if it were to develop the gas field without the contracts and then subsequently sell the gas on a short-term market. These two sets of price scenarios can then used as inputs to a traditional discounted cash flow analysis. The difference between the NPV calculated with the contracts and the NPV calculated for the short-term sales is the value that would be lost on average if the firm were to develop the project without the contracts. We refer to this difference as the 'strategic value' of long-term contracts to the specified project. This paper therefore provides a financial analyst with a subroutine that can be conveniently appended to the standard capital budgeting analysis to aid in assessing the importance of the long-term contracts to the profitability of a given project.

We illustrate the use of this model with a pair of natural gas projects considered for development in East Asia. Each of the projects was designed for export of LNG to Japan. The projects we consider differ markedly in the capital costs necessary to export at an efficient scale and the results demonstrate that that this factor significantly influences the importance of long-term contracts to the different projects. The main conclusion that one draws from these examples is that the benefit of a long-term contract and the possibility for switching to more flexible arrangments is project specific and not a general character of the natural gas market. This highlights the importance of having a technique for assessing on a project-by-project basis the benefits that the use of contracts yield.

PROJECT VALUATION AND THE VALUE OF A CONTRACT

We begin the analysis with a standard discounted cash flow (DCF) analysis of an LNG export project considered for development in Australia.[1] A DCF analysis will be calculated once for the project when the output is sold under long-term contracts and once for the project when the output is to be sold under short-term sales agreements. The difference in NPV for the two cases will be our measure of the 'strategic value' of long-term contracts for this project.

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[1] The basic cost data and the market price scenarios for this and other examples in this paper are taken from Adelman et al. (1986). The examples used here are meant exclusively as illustrations of the mechanics and the intuition behind the model: our objective is not a thorough evaluation of the data and viability of the actual fields.

The field has a production capacity of 7 million tons of LNG per year. Total planned expenditures for capital investment are $5.82 billion to be spent over 10 years. Production is planned to begin in 1989 and to rise slowly until capacity is reached in 1993. From this date production would be constant for twenty years until the year 2012. A DCF analysis is displayed in Table 1. Incorporating the expenditure and production schedules and a real discount factor of 12% the allocated capital charge would be $2.29/Mcf. Mean operating costs would be $0.87/Mcf bringing the total allocated costs to $3.16/Mcf. At an expected sale price of $3.85/Mcf the project NPV is $1.189 billion.

[Insert Table 1]

According to contemporaneous analyses of demand $3.85/Mcf was a sensible expectation of the price that could be successfully negotiated for a long-term take-or-pay contract, and so $1.189 billion is a reasonable expectation of project NPV using long-term contracts.

We now turn our attention to the alternative of developing the field and constructing the LNG facilities without the traditional long-term contracts. Our objective is to determine the project NPV that the developer can anticipate under this alternative. Accordingly we suppose that the field is developed and LNG capacity installed according to the schedules given above. We then determine the likely price at which the LNG could be successfully marketed under short-term sales agreements and make a similar DCF calculation of the project NPV under short-term sales.

The key difference between the price that can be negotiated for the long-term contracts and the price that can be negotiated for future short-term sales is that the developer negotiates the long-term contract price prior to installing the capacity while the developer will negotiate the price for short-term sales after capacity has already been installed. The Australian LNG project is targetted to a small number of potential buyers--the major power utilities in Japan--and the capacity that is to be

Table 1

DCF Analysis: Australian LNG Project Using Long-Term Contracts

Capital Expenditures	$ 5.82 billion
Peak Output	365 Bcf/year
Capital Charge	$ 2.29 /Mcf
Operating Cost	$ 0.87 /Mcf
Total Alloc. Cost	$ 3.16 /Mcf
Contract Price	$ 3.85 /Mcf

Year	Capital Expenses ($ m)	Quantity Sold (m Mcf)	Revenues ($ m)	Operating Costs ($ m)	Net Cash Flow ($ m)
1985	430				-430
1986	580				-580
1987	990				-990
1988	840				-840
1989	580	150	578	131	-133
1990	760	180	693	157	-223
1991	910	220	847	191	-254
1992	290	330	1270	287	693
1993	290	370	1425	322	813
1994	160	370	1425	322	943
1995	0	370	1425	322	1103
1996	0	370	1425	322	1103
1997	0	370	1425	322	1103
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2011	0	370	1425	322	1103
2012	0	370	1425	322	1103

NPV @ 12% = $ 1,189 billion

installed, especially for shipment of the LNG, will be effectively dedicated to these buyers. Since the market for this project's LNG is not perfectly competitive, the installation of capacity significantly alters the strategic factors influencing the price negotiations between the developer and the small number of potential buyers. Given the same overall demand conditions, the seller should expect that if it first installs capacity and then negotiates the short-term sales, it will obtain on average a price that is lower than it would successfully negotiate for a long-term contract. Depending upon future events the exact realized future short-term price may be higher or lower than the long-term contract price, but the average will be biased downward from the long-term contract price. This is a common feature of projects in the natural gas industry and is one of the key reasons for the predominance of long-term contracts. These issues are the subject of a recent literature in the field of industrial organization under the heading the 'ex-post bargaining problem' and their consequence for the structure of contracts in industries such as coal and electrical generation have recently been documented.[2]

This benefit of the long-term contracts can be illustrated in a comparison of the likely price scenarios for contract and short-term gas sales. In Figure 1 we display two probability distributions over price for sales from the LNG project discussed above--one distribution for long-term contract prices and one for short-term sales prices. The distribution for the long-term contract price has a mean of $3.85/Mcf. This is the price that was used in Table 1 above to calculate the NPV of the Australian project under long-term contracts. The second probability distribution is for short-term sales. As one can see the distribution for short-term sales is shifted downward in accordance with the theory referenced above: the mean short-term sales price is \$3.53/Mcf. Using this price to calculate the NPV for the LNG project when the full capacity is sold on a short-term basis yields a project NPV of \$0.642 billion as shown in Table 2. That is \$547 million or 46% less than the NPV expected from development under long-term contracts.

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[2] The seminal articles on ex-post opportunistic bargaining are Williamson (1975) and (1979), and Klein, Crawford, and Alchian (1978). For empirical work on the organizational structure of the coal and electrical generating industries see Joskow (1985) and (1987).

[Insert Figure 1 and Table 2]

It is the security against this worsened bargaining position and lowered price that motivates the use of long-term contracts. The \$547 million difference in project NPV is secured to the developer through the decision to use long-term contracts and to make the installation of capacity contingent upon their successful negotiation. This is what we call the 'strategic value' to the use of long-term take-or-pay contracts for the Australian project.

To this point we have not provided the model with which we calculated the shift in price distributions displayed in Figure 1. However, our example illustrates the idea that we want our model to capture. When a corporation decides to make the development of a field contingent upon the successful completion of long-term contracts or when a bank or other source of finance makes the use of its funds contingent upon the negotiation of long-term contracts then they are implicitly assessing the magnitude of this price shift to be large. They are implicitly calculating the 'strategic value' to long-term contracts and deciding that for the project at hand it is significant. The objective of this paper is to provide a technique with which to assess the significance of this shift in the price distribution on the basis of fundamental data about the particular project and the market to which the product is aimed. Our method for estimating the 'strategic value' of the long-term contracts uses a model of the market that has become commonplace in the economics literature and that can be easily integrated into the classical DCF framework.

Figure 1

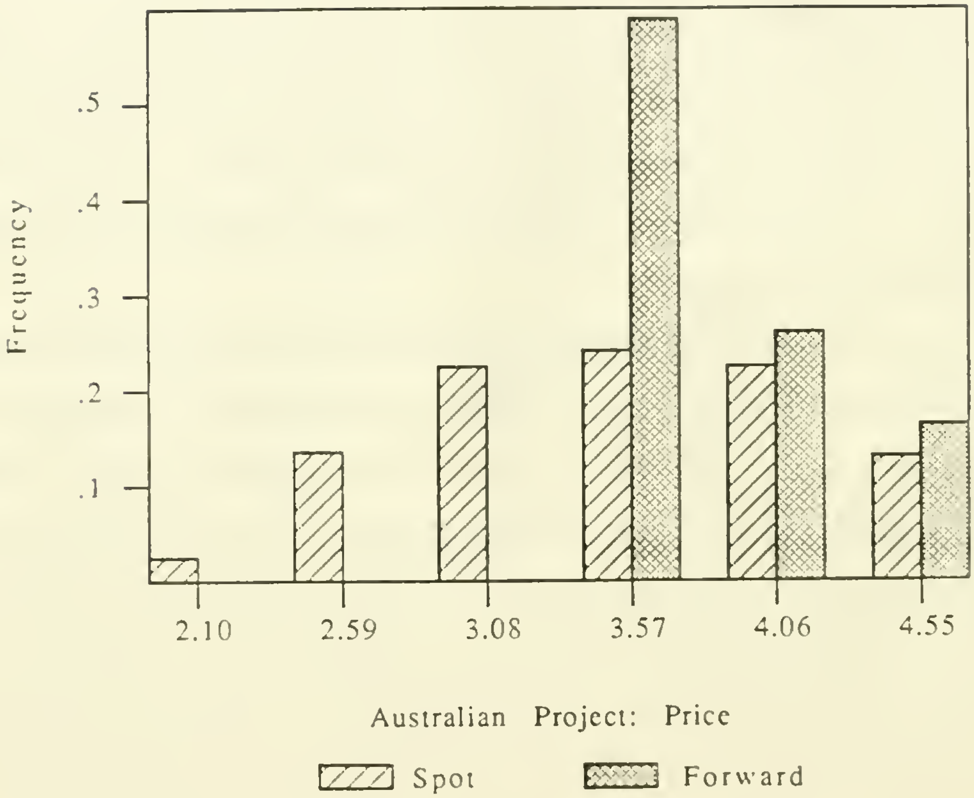
Frequency
.5
.4
.3
.2
.1
2.10
2.59
3.08
3.57
4.06
4.55
Australian Project: Price
Spot
Forward

Table 2

DCF Analysis: Australian LNG Project Using Short-Term Sales

Capital Expenditures	$ 5.82 billion
Peak Output	365 Bcf/year
Capital Charge	$ 2.29 /Mcf
Operating Cost	$ 0.87 /Mcf
Total Alloc. Cost	$ 3.16 /Mcf
Avg. Short-Term Price	$ 3.53 /Mcf

Year	Capital Expenses	Quantity Sold (m Mcf)	Revenues ($ m)	Operating Costs ($ m)	Net Cash Flow ($ m)
1985	430				-430
1986	580				-580
1987	990				-990
1988	840				-840
1989	580	150	530	131	-181
1990	760	180	635	157	-281
1991	910	220	777	191	-325
1992	290	330	1165	287	588
1993	290	370	1306	322	694
1994	160	370	1306	322	824
1995	0	370	1306	322	984
1996	0	370	1306	322	984
1997	0	370	1306	322	984
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2011	0	370	1306	322	984
2012	0	370	1306	322	984

NPV @ 12% = $ 0.642 billion

AN AUCTION MODEL OF NEGOTIATIONS

To estimate the shift from the probability distribution of long-term contracts prices to the probability distribution for short-term sales prices we use an auction model of negotiations. Many factors enter into the dynamics of actual contract and sales negotiations and any model must abstract from some factors in order to isolate the effects of other factors. Our objective is to assess the importance of the capacity installation decision and the timing of the sales negotiations in determining the outcome of the negotiations. We model the seller's negotiation for long-term contracts as an auction of the field capacity to the potential buyers where that auction is conducted prior to the installation of the capacity; and we model the seller's negotiation for short-term sales agreements as an auction of the capacity after the capacity has been installed.

The auction model we use has been extensively analyzed in the economics literature: the basic structure is as follows.[3] The seller announces the quantity of LNG that will be for sale and the minimum bid that will be allowed. Buyers determine their own valuation of the gas and submit a bid at which they would be willing to buy it. The seller gathers the bids and ranks them. The capacity is allocated to those buyers who have submitted the highest bids. The price charged all of the buyers with winning bids is the highest bid not accepted. If not enough buyers submit bids above the minimum to exhaust capacity, then the project is scaled down and the bidders that can pay the minimum bid are serviced. In this case the buyers are charged the minimum bid. This type of auction is a close approximation to a competitive market. As the number of potential buyers increases then the results of the auction become identical with the allocations and prices that would arise in a competitive market. The auction is optimal from the viewpoint of the seller in the sense that it maximizes the expected profits from the sale.

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[3] For the basic auction model see Harris and Raviv (1981). For a description of the model as applied to sales negotiations of natural gas see Parsons (1988). A personal computer simulation model of the auction is documented in Barudin, Ellis and Parsons (1987).

The key inputs to the auction model are: (i) the maximal capacity of the natural gas field and liquefaction facility planned, (ii) the capital charge per Mcf, (iii) the operating cost per Mcf, (iv) the number of potential buyers, (v) the fraction of capacity that the typical buyer would purchase, and (vi) a range of possible reservation values denoting the maximum price that a buyer would pay for the gas. This last input is the key to the probabilistic character of the model. Prior to entering into negotiations the seller may have some idea of the price that each buyer would be willing to accept, but the seller is assumed to be somewhat uncertain of the exact price. Each buyer is also uncertain about the price that competing buyers would be willing to pay and this uncertainty will influence their bidding strategy. We represent this uncertainty as a range of possible valuations on the part of the buyers and a probability distribution over this range. The model constructs a full set of possible combinations of numbers of buyers at various reservation values and the associated probability of that combination. For each possible combination of buyers at various reservation values the model calculates the outcome of the auction for long-term contracts and the outcome of the auction for short-term sales and then generates a probability distribution of prices charged and quantities sold for both the long-term contracts and the short-term sales. Then the model calculates the total expected profit from long-term contracts and from short-term sales based upon the probabilities of each event and the results of the auction for each event.

The rules of the auction for long-term contracts and the auction for short-term sales differ only in that the seller imposes a different minimum bid on the two auctions. If the auction is run prior to the installation of capacity, then the seller would never agree to a contract price that is less than the sum of the allocated capital charge per Mcf and the operating cost per Mcf. If, however, the auction is run after the capital investment is sunk, and if the seller has no alternative buyers, then the seller would consider a short-term sale price that does not fully cover the capital charges. The minimum bid in the auction for long-term contracts would therefore be the total allocated cost per Mcf. The minimum bid in the short-term sales auction would be just the operating cost per Mcf. This is the key factor that determines the different price distributions that result from an auction held prior to the installation of capacity--an auction for long-term contracts--and an auction held after the capital costs are sunk--an auction for short-term sales. There will be certain combinations of buyers at reservation values for which the price from the long-term auction is higher than the price for the short-term auction. There will also be cases in which the price obtained for short-term sales does not fully cover the capital charges: in the auction for long-term contracts the minimum bid is set equal to the fully allocated cost and therefore either the buyers pay this price, or the project is scaled down and the danger of losses is eliminated. For a detailed examination of the auction model and the possible outcomes for both the long-term and the short-term negotiations see Parsons (1988).

THE VALUE OF CONTRACTS IN EAST-ASIAN LNG PROJECTS

To demonstrate the use of this model we will analyze two different LNG projects that have been considered for export to the Japanese market. The first is the Australian project described above. This will be our high capital cost case. The second example will be an LNG export project proposed for Indonesia. The capital costs for the Indonesian project are much lower than for the Australian project. While it is obvious that the lower cost project has a higher profit margin, we are concerned not with estimating the NPV itself, but with estimating the portion of the NPV that is secured specifically through the use of the long-term sales contracts. We will show that our model allows us to differentiate projects for which the long-term contracts are an essential component from projects that can be organized without stringent long-term take-or-pay contracts.

A High Capital Cost Example: the Australian Project

As calculated above, the NPV of the Australian project for an expected long-term contract price of \$3.85 is \$1.189 billion. An expected long-term contract price of \$3.85 is calculated by our auction model run with the following parameters. The field has a maximal annual capacity of 370 Bcf. There are 3 potential buyers, each of which would purchase the full capacity: i.e., long-term contract negotiations are simulated as an auction of 1 unit to 3 buyers. The marginal cost input to the auction for long-term contracts is the sum of per unit capital and operating costs--\$3.16/Mcf. This will determine the minimal bid in the auction for long-term contracts. In the auction for short-term sales the minimum bid will be determined by the unit operating costs of \$0.87/Mcf. We assume that each of the three potential buyers values the natural gas at a price somewhere between \$2.10 and \$4.55/Mcf and we assume for each buyer an independent uniform distribution over a set of six discrete points on this range of prices. From the distribution for each buyer we generate a probability distribution across all possible combinations of the three buyers' reservation values. This is the full set of inputs that we need in order to calculate the 'strategic value' of contracts using our auction model.

With this set of inputs our auction model generates a full set of possible outcomes for long-term contract negotiations and for short-term sales. For the specified parameters the resulting distributions over long-term contract prices and over short-term sale prices are the two distributions that were displayed above in Figure 1. The average long-term contract price is $3.85 and the average short-term sales price is $3.53.

The model also generates information on the likelihood that contract negotiations are not succesfully completed or that short-term sales are not made. For example, in the case of negotiations for long-term contracts there will arise some events in which the realized buyer reservation values are uniformly below the marginal cost of production inclusive of capital costs. In these events none of the potential buyers would accept the minimum bid set by the developer and no long-term sales would be executed. This is the event that the planned LNG project is cancelled due to a lack of demand as revealed in the course of negotiations. In the case of the Australian LNG export project the model estimates that this occurs with a probability of 12%. Cancelling the project in this event is an important decision. It saves the developer the capital charges when the market would not give the developer a return sufficient to recoup the charges. If the developer were to build the capacity and only subsequently attempt short-term sales, the price in these events would be below the fully allocated cost, and the developer would incur a loss. The model incorporates this avoided loss in its estimate of the 'strategic value' to forward contracting.

Key parameters and model results for the Australian case are summarized in Table 3. The expected annual profits to selling the 370 Mcf under long-term contracts are $223 million--incorporating sales 88% of the time and an average price in sales of $3.85. Over the full life of the project the expected NPV would be $1.046 billion. This is lower than the $1.189 billion in Table 1 since here we have incorporated the probability that no sales are made: the value in Table 1 is the expected NPV conditional on a successful sale at the average contract price of $3.85. The expected annual profits from short-term sales are $137 million, incorporating sales 100% of the time and an annual price of $3.53. The expected NPV for the short-term sales over the full life of the project is therefore $642 million. The difference between the expected NPV under long-term contracts and under short-term sales is $404 million or 39% of the project NPV. This is our measure of the 'strategic value' of the long-term contracts for this project: it is a measure of the security gained through the decision to make development of the project contingent upon the succesful completion of long-term contracts.

[Insert Table 3]

A Low Capital Cost Example: An Indonesian LNG Project

Long-term contracts are not equally important for securing the NPV of all gas projects: we now analyze an Indonesian LNG export project for which our model assesses the 'strategic value' of long-term contracts to be zero. The key difference between the Australian and the Indonesian LNG projects is the size of the up-front capital expenses relative to the lower tail of the probability distribution over buyer reservation values.

The LNG project in Indonesia involves the development of a 6 million ton per year field and liquefaction facility. The LNG is also to be exported to the Japanese market. Capital expenditures include the construction of field facilities, a liquefaction plant, a regasification plant, and shipping capacity to generate a maximum annual LNG export capacity of 300 Bcf/year. Total capital expenditures will be $2.6 billion incurred over a 5 year period. The field will have a projected life of 24 years. Operations begin in 1989 and rise to full capacity in 1993. The planned schedules for capital expenditures and for production are displayed in Table 4 below. Allocated across the planned schedule of production, the per unit capital costs are $1.38/Mcf. Operating costs are assumed constant at $0.55/Mcf. At a long-term contract price of $3.85/Mcf the project NPV would be $2.86 billion.

Table 3

Summary of Auction Model Results for the Australian LNG Project

	Short-Term Sales	Contract Sales
Capital Charge	$ 2.29 /Mcf	$ 2.29 /Mcf
Operating Cost	$ 0.87 /Mcf	$ 0.87 /Mcf
Total Allocated Cost	$ 3.16 /Mcf	$ 3.16 /Mcf
Expected Sale Price	$ 3.53 /Mcf	$ 3.85 /Mcf
Expected % Capacity Sold	100 %	88 %
Annual Profits @ Max Output	$ 137 mil.	$ 223 mil.
Total Project NPV	$ 642 mil.	$1,046 mil.
Difference / Strategic Val.	$ 404 mil.	39%

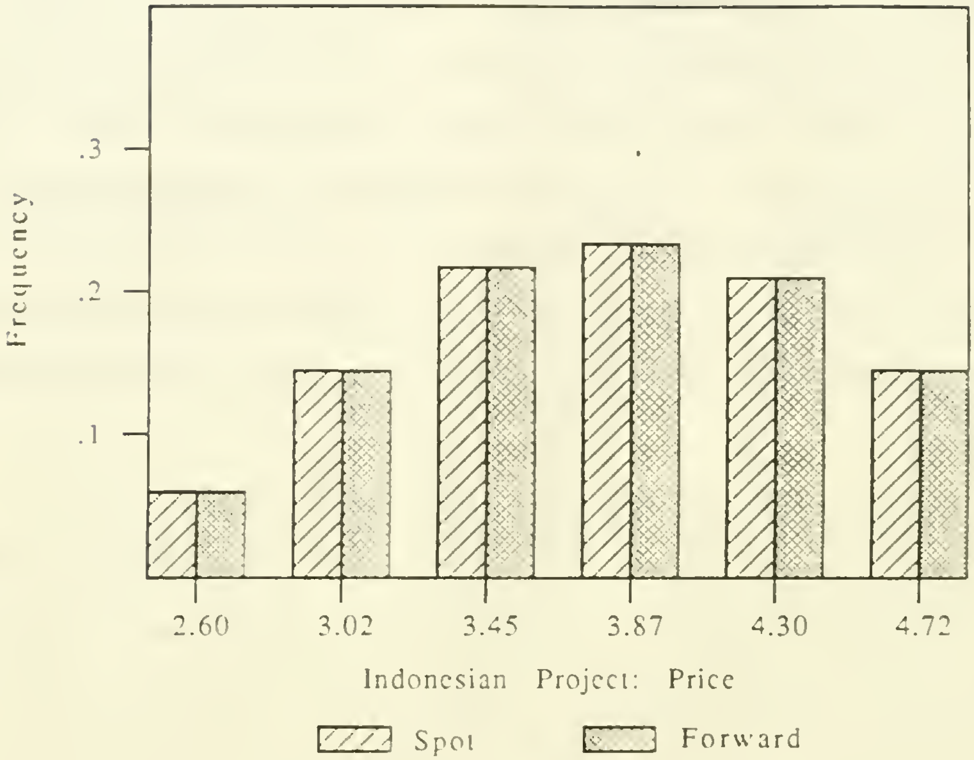
To estimate the portion of the NPV that is secured to the developer through the use of long-term contracts for this low capital cost project we determine the necessary inputs to our auction model. Since the project is designed to sell LNG to the same market as the Australian project the parameters for market demand are similar to those used in the Australian example: (i) 3 buyers, each of which can purchase the full capacity, and (ii) a uniform distribution of buyer reservation values over the range $2.60-$4.72/Mcf. The minimum bids in the auction are different from the Australian example and this is the important difference between the two cases. The minimum bid for long-term contracts is determined by the sum of capital and operating charges per unit--$1.93/Mcf. The minimum bid in the auction for short-term sales is determined by the operating costs of $0.55/Mcf.

In the auction for long-term contracts the expected price is $3.85/Mcf. Sales occur with 100% probability in this example. In the short-term auction the average price is also $3.85. The price distribution for long-term contract sales and short-term sales are identical in these two cases as can be seen in Figure 2 below. This occurs because the

[Insert Figure 2 and Table 4]

capital costs for the Indonesian project are so low that the price in both the long and the short-term sales is determined exclusively by competition among the buyers. The minimum bid as determined by the sum of capital and operating charges is never the determining factor in negotiations over price. In this example, the seller's bargaining power is not diminished by the installation of capacity. Therefore, long-term contracts do not serve the purpose of preserving this project's value against opportunistic ex-post bargaining practices on the part of the buyers. Since the anticipated price distributions for the long-term contract sales and for short-term sales are identical the NPV of the project is constant across these two

Figure 2



Frequency
.3
.2
.1
2.60
3.02
3.45
3.87
4.30
4.72
Indonesian Project: Price
▨ Spot
▩ Forward

Table 4

DCF Analysis: Indonesian LNG Project

Capital Expenditures	$ 2.60 billion
Peak Output	300 Bcf/year
Capital Charge	$ 1.38 /Mcf
Operating Cost	$ 0.55 /Mcf
Total Alloc. Cost	$ 1.93 /Mcf
Contract Price	$ 3.85 /Mcf
Avg. Short-Term Price	$ 3.85 /Mcf

Year	Capital Expenses ($ m)	Quantity Sold (m Mcf)	Revenues ($ m)	Operating Costs ($ m)	Net Cash Flow ($ m)
1985	150				-150
1986	500				-500
1987	880				-880
1988	800				-800
1989	300	180	693	99	294
1990	0	210	808	116	693
1991	0	240	924	132	792
1992	0	270	1040	149	891
1993	0	300	1155	165	990
1994	0	300	1155	165	990
1995	0	300	1155	165	990
1996	0	300	1155	165	990
1997	0	300	1155	165	990
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2011	0	300	1155	165	990
2012	0	300	1155	165	990

NPV @ 12%

long-term contract = $ 2,861 billion

short-term sales = $ 2,861

Difference / strategic value = 0

financing/marketing alternatives and accordingly our model calculates the 'strategic value' of long-term contracts to be zero in this case.

CONCLUSIONS

It is commonly understood that long-term take-or-pay contracts for natural gas provide the seller with a minimal degree of security about the return to a project. This security has been a necessary prerequisite to the large scale capital investments that are needed in this industry. In recent years, however, a significant amount of increased flexibility has arisen in the organization of natural gas projects. Contracts themselves have become more flexible, and increasingly developers have considered the option of investing in capacity without having successfully negotiated take-or-pay contracts for the full output. To date, however, project analysts have been without a tool to assess the significance of the security offered to them by long-term contracts, and therefore have been without a means to provide a quantitative answer to the question about whether it would be prudent to invest the capital absent these contracts. In this paper we have provided a model with which to make this assessment.

The model presented in this paper calculates the different probability distributions over price that the seller can anticipate for long-term contracts and for short-term sales. The two distributions are calculated simultaneously based upon the same fundamental data regarding project size and cost and the market for which the natural gas is targetted. The model calculates the expected quantity of sales for long-term contracts and for short-term sales and calculates a Net Present Value for the project for both cases. The difference between the two NPV's represents the portion of the project NPV that is secured or insured by the use of long-term contracts: the 'strategic value' of long-term contracts.

The model's use was illustrated with two cases: an Australian and an Indonesian LNG export project. The result established above that long-term contracts are essential to the value of the Australian project but not to the Indonesian project was critically dependent upon the particular specification of the parameters for each project. Key to the result was the size of the capital charge in relation to the lower range of prices that would arise in negotiations with the buyers. In the Australian example the capital charge was significantly greater than the lower end of the price distribution that would have followed from competition. In the Indonesian example the capital charge was below the lower end of the price distribution that would have followed from competition. It is not possible to assess the 'strategic value' of long-term contracts simply from eyeballing the relative capital charges of the two projects. What is necessary is an assessment of the likelihood that the negotiated price would fall below this charge. The auction model generates a probability distribution across negotiated prices and therefore allows us to assess this likelihood.

Tradition in the natural gas industry has it that long-term contracts are an essential element of financing LNG projects. An important conclusion that arises from our two examples is that although this may be true in general, it is possible to identify specific projects whose cost structure and product market structure are such that long-term contracts contribute little to securing the project NPV. This model enables us to assess the significance of the contribution of long-term contracts on a project-by-project basis and therefore to identify exceptions to this rule.

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